

AD-A200 732

## REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION <b>UNCLASSIFIED</b>		1b. RESTRICTIVE MARKINGS													
2a. SECURITY CLASSIFICATION AUTHORITY <b>UNCLASSIFIED</b>		3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution unlimited.													
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE															
4. PERFORMING ORGANIZATION REPORT NUMBER(S)		5. MONITORING ORGANIZATION REPORT NUMBER(S) <b>AFOSR-TR. 88-1079</b>													
6a. NAME OF PERFORMING ORGANIZATION Washington State University OCT 13 1988		7a. NAME OF MONITORING ORGANIZATION AFOSR/NE													
6c. ADDRESS (City, State and ZIP Code) Pullman, Wa		7b. ADDRESS (City, State and ZIP Code) Bldg 410 Bolling AFB DC 20332-6448													
8a. NAME OF FUNDING/SPONSORING ORGANIZATION AFOSR	8b. OFFICE SYMBOL (If applicable) NE	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER AFOSR-88-0158													
8c. ADDRESS (City, State and ZIP Code) Bldg 410 Bolling AFB DC 20332-6448		10. SOURCE OF FUNDING NOS. <table border="1"><tr><td>PROGRAM ELEMENT NO. 61102F</td><td>PROJECT NO. 2306</td><td>TASK NO. A1</td><td>WORK UNIT NO.</td></tr></table>		PROGRAM ELEMENT NO. 61102F	PROJECT NO. 2306	TASK NO. A1	WORK UNIT NO.								
PROGRAM ELEMENT NO. 61102F	PROJECT NO. 2306	TASK NO. A1	WORK UNIT NO.												
11. TITLE (Include Security Classification) International Conference on Superplasticity and Superplastic Forming															
12. PERSONAL AUTHOR(S) Hamilton															
13a. TYPE OF REPORT Final	13b. TIME COVERED FROM 01-04 Augo	14. DATE OF REPORT (Yr., Mo., Day)	15. PAGE COUNT												
16. SUPPLEMENTARY NOTATION															
17. COSATI CODES <table border="1"><tr><th>FIELD</th><th>GROUP</th><th>SUB. GR.</th></tr><tr><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td></tr></table>		FIELD	GROUP	SUB. GR.										18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number) Superplasticity and Superplastic Forming	
FIELD	GROUP	SUB. GR.													
19. ABSTRACT (Continue on reverse if necessary and identify by block number) It was apparent from the papers presented that the research and development activity in the area of superplasticity and superplastic forming is of substantial interest world-wide, and a number of papers reported results that are considered to be significant and which may point the direction for future research that should prove fruitful. Noteworthy among these are 1) the activities addressing high rate superplasticity, through both alloy development and process concept studies, 2) computer modeling of the SPF process, including finite element methods coupled with 3-D color graphics displays of thinning characteristics, 3) superplasticity in ceramic and inter-metallic compound materials, 4) solid-state joining (diffusion bonding) of aluminum alloys, 5) demonstration that there are microstructural concepts other than that of fully recrystallized structure which can lead to superplasticity, especially at high rates, and 6) significant extension in the state of understanding of the interrelationship between microstructural dynamics and superplastic properties, including fundamentals of superplasticity and cavitation.															
20. DISTRIBUTION/AVAILABILITY OF ABSTRACT UNCLASSIFIED/UNLIMITED <input type="checkbox"/> SAME AS RPT. <input type="checkbox"/> DTIC USERS <input type="checkbox"/>		21. ABSTRACT SECURITY CLASSIFICATION <b>UNCLASSIFIED</b>													
22a. NAME OF RESPONSIBLE INDIVIDUAL Rosenstein		22b. TELEPHONE NUMBER (Include Area Code) (202) 767-4933	22c. OFFICE SYMBOL NE												

**AFOSR-TX- 88-1079**

**FINAL REPORT**

**INTERNATIONAL CONFERENCE ON SUPERPLASTICITY  
AND SUPERPLASTIC FORMING**

August 1-4, 1988

Blaine, Washington

Report To

Air Force Office of Scientific Research  
(Contract No. AFOSR88 0158)

C. H. Hamilton  
Washington State University  
Pullman, WA

N. E. Paton  
Rockwell International  
Canoga Park, CA

August 9, 1988



Accession For	
NTIS GRA&I	<input checked="" type="checkbox"/>
DTIC TAB	<input type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification	
By	
Distribution	
Date	
Initials	
A-1	

The International Conference on Superplasticity and Superplastic Forming was held at the Inn at Semiahmoo in Blaine, WA on 1-4 August, 1988. There were 144 attendees registered, and approximately 107 papers were presented, including 67 oral presentations and 40 posters. Attendees represented 17 different countries. Enclosed are copies of the program and list of attendees. The proceedings will be published by The Metallurgical Society, and should be available about November, 1988. Copies will be forwarded to AFWAL when they are available.

It was apparent from the papers presented that the research and development activity in the area of superplasticity and superplastic forming is of substantial interest world-wide, and a number of papers reported results that are considered to be significant and which may point the direction for future research that should prove fruitful. Noteworthy among these are 1.) the activities addressing high rate superplasticity, through both alloy development and process concept studies, 2.) computer modeling of the SPF process, including finite element methods coupled with 3-D color graphics displays of thinning characteristics, 3.) superplasticity in ceramic and intermetallic compound materials, 4.) solid-state joining (diffusion bonding) of aluminum alloys, 5.) demonstration that there are microstructural concepts other than that of fully recrystallized structure which can lead to superplasticity, especially at high rates, and 6.) significant extension in the state of understanding of the interrelationship between microstructural dynamics and superplastic properties, including fundamentals of superplasticity and cavitation development.

It is now clear that the concepts of superplastic forming as being a slow forming process (ie., requiring times of the order of 15 minutes to several hours) are no longer valid. Superplasticity at strain rates in the range of .1 to  $2.5 \text{ s}^{-1}$  have been reported. For example, the work of Beiler et al (paper 60), Matsuki et al (paper 84), and Ghandi et al (paper 14) clearly show that very high rate superplasticity is possible, especially if dynamic recrystallization processes are involved during the superplastic deformation. In addition, concepts of variable strain rate deformation processing, rather than constant strain rate, also hold promise for increasing the SPF process rate as

indicated by Ohsawa (paper 61), Ash et al (paper 42), and Ghosh (paper 68).

Perhaps the most exciting new developments in superplasticity are those in the area of "difficult-to-form" materials, such as the ceramics, intermetallic compounds, composites and mechanically alloyed metals. For example, it was reported that a ceramic material (Y-TZP  $\text{ZrO}_2$ ) was just recently stretched in tension to an elongation of over 900%, and exceptional achievement (paper 9). Superplastic forming appears to offer an effective way of shaping many other materials, such as Ti aluminides and other intermetallic compounds, as well as certain metal matrix composites.

The applications of SPF parts continues to increase both in aerospace and non-aerospace areas. Titanium continues to be the primary material processed for aerospace, although the development in Al SPF is accelerating and utilization is increasing as new commercial alloys become available. A number of Ti, Al, Fe, and Ni alloy parts were shown by the European, Chinese, and Russian authors (eg. papers 1,22, 26, 27, 52, 76, 77, 78, 97, 106, and 107).

It is noteworthy that in several countries, there are nationally coordinated research groups on superplasticity. Such groups include the Japan Research Group on Superplasticity, a similar group in the Peoples Republic of China, a Center for the Study of Superplasticity Problems in the USSR with 500 researchers, and group recently established in the United Kingdom for exchange of ideas and information on superplasticity.

The Organizers decided to establish a "Best Paper" award for the manuscripts submitted for the Conference, and present the author(s) with a \$500 honorarium. The award was based on the written manuscripts only. The award was presented to T. R. Bieler, T. G. Nieh, J. Wadsworth, and A. K. Mukherjee for their paper "*High Rate Superplastic Behavior of Mechanically Alloyed Al IN90211*" (paper 60) based on the significance, technical quality and clarity of their paper.

The Organizing Committee met during the Conference to discuss the interest and research progress in superplasticity, and to explore the need for future conferences. It was the conclusion of the Committee that interest in superplasticity and related progress were sufficient to justify a subsequent international conference, and it was agreed

that Japan would host the next conference, and that it would be scheduled for 1991. The specific site and date will be identified at a later date by the Japanese members of the Organizing Committee.

The following Appendices include the list of attendees and a copy of the program for the Conference.

## **APPENDIX A**

### **PROGRAM**

**International Conference on Superplasticity  
and Superplastic Forming**

# INTERNATIONAL CONFERENCE ON SUPERPLASTICITY AND SUPERPLASTIC FORMING

## TECHNICAL PROGRAM

### SUNDAY, JULY 31

15:30 - 19:00 Registration in Ballroom Lobby

17:00 - 19:00 Social Mixer featuring a San Francisco pasta bar, beer and wine in Blakely Room

### MONDAY, AUGUST 1

7:00 - Registration and coffee/pastries in Ballroom Hallway

8:00 - Welcoming Comments - C. Howard Hamilton, Conference Co-Chair

All meetings will be held in the Cypress and Orcas Rooms.

-----

### MONDAY, AUGUST 1

#### SESSION I: FUNDAMENTALS

Chair: C. Howard Hamilton, Washington State University, U.S.A.

#### Keynote Speaker

- |       |         |   |
|-------|---------|---|
| 8:15  | Paper 1 | O. A. KAIBYSHEV, USSR Academy of Sciences<br><i>Current Problems of the Material Science of Superplasticity</i>   |
| 8:50  | Paper 2 | SHIGENORI HORI and NORIO FURUSHIRO, Osaka University<br><i>Metallographical Research on Superplasticity</i>   |
| 9:10  | Paper 3 | M. J. MAYO, Sandia National Laboratories and W. D. NIX, Stanford University<br><i>Direct Observations and Micromechanical Testing of Superplastic Alloys</i>  |
| 9:30  | Paper 4 | G. S. MURTY, Indian Institute of Technology and M. J. KOCZAK, Drexel University<br><i>Investigation of Region I in Rapidly Solidified Powder Al Alloys</i>  |
| 9:50  |         | Break   |
| 10:10 | Paper 5 | R. I. TODD and P. M. HAZZLEDINE, Oxford University<br><i>The Mechanism of Superanelasticity and its Implications</i>  |
| 10:30 | Paper 6 | SHANYOU ZHOU, LIQIN WANG and CHIN LIU, Shanghai Jiao Tong University<br><i>The Role of Grain Boundary Dislocations During Superplastic Deformation of an Al Alloy</i>   |
| 10:50 | Paper 7 | R. Z. VALIEV, USSR Academy of Sciences<br><i>The Physical Model of Superplasticity Based on the Notion of Non-equilibrium Grain Boundaries</i>  |
| 11:10 | Paper 8 | G. TORRES VILLASEÑOR, Universidad Nacional Autónoma de México and J. NEGRETE, Universidad Autónoma de San Luis Potosí<br><i>Superplastic Behavior of Zn-20Al-2Cu at Room Temperature and Deformation Mechanisms</i> |

11:30 Paper 9 J. WADSWORTH, T. G. NIEH, Lockheed Missiles & Space Company, Inc.,  
and OLEG SHERBY, Stanford University  
*Some Recent Advances in the Development of Fine-grained Superplastic Al  
Alloys, Ceramics, and Laminated Composites*

12:15 Lunch in Blakely Room

-----  
**MONDAY, AUGUST 1**

**SESSION II: MICROSTRUCTURAL DYNAMICS**

Chair: Peter Partridge, Royal Aircraft Establishment, England

**Keynote Speaker**

13:50 Paper 10 D. S. WILKINSON, McMaster University  
*Microstructural Instability During Superplastic Flow*

**Keynote Speaker**

14:25 Paper 11 R. GRIMES, Alcan International Limited  
*Microstructural Evolution in Superplastic Al Alloys*

15:00 Paper 12 N. G. ZARIPOV and R. O. KAIBYSHEV, USSR Academy of Sciences  
*Dynamic Recrystallization and Superplasticity of a Mg Alloy*

15:20 Break

15:40 Paper 13 JIN QUANLIN, BAI BINGZHE, LAI WEIHUA, GUO XUSHENG and  
ZHANG HONG, Beijing Research Institute of Mechanical and Electrical  
Technology of SIME  
*Grain Refinement by Torsion and Superplasticity in High-strength Al Alloy*

16:00 Paper 14 CHIMATA GANDHI and AMIT K. GHOSH, Rockwell International Science  
Center  
*Superplasticity in High-strength Al Alloys*

16:20 Paper 15 G. A. SALISHCHEV and R. Ya. LUTFULLIN, USSR Academy of Sciences  
*The Transformation of Ti Alloy Laminar Microstructure into a Microduplex One*

16:40 Paper 16 P. LUKÁČ, Charles University  
*The Role of Matrix Dislocations in the Superplastic Deformation*

17:00 Paper 17 EIICHI SATO, KAZUHIKO KURIBAYASHI AND RYO HORIUCHI, The  
Institute of Space and Astronautical Science  
*Superplastic Deformation Induced Grain Growth in Microduplex and Second  
Phase Dispersed Alloys*

Dinner on your own.  
-----

**SESSION III: POSTER SESSION**  
20:30 - 22:30 in the Ballroom Lobby

Paper 18 D. V. DUNFORD and P. G. PARTRIDGE, Royal Aircraft Establishment  
*Deformation of Ti-6Al-4V Bar and Extrusion Under Superplastic Forming Conditions*

Paper 19 N. DYULGEROV, A. ISTATKOV, N. MITEV, and I. SPIROV, Bulgarian Academy  
of Sciences  
*Superplastic Low Manganese Zinc-Manganese Alloys*



- Paper 20 P. GRUFFEL, P. CARRY and A. MOCELLIN, École Polytechnique Fédérale de Lausanne  
*Effect of Testing Mode on Superplastic Creep of Fine Grained Alumina*
- Paper 21 K. OSADA, Nippon Yakin Kogyo Co., Ltd.  
*Properties of a Microduplex Stainless Steel Superplastically Deformed*
- Paper 22 R. FURLAN, P.-J. WINKLER, MBB Central Laboratories, D. HAGG and L. REISINGER, MTU Development Manufacturing  
*Production of Ti-6Al-4V-Components for a New Turbo-Fan-Engine*
- Paper 23 R. A. RICKS, J. BALL, Alcan International Limited; H. STOKLOSSA, MBB Central Laboratories, P.-J. WINKLER, MBB Central Laboratories, and R. GRIMES, British Alcan Aluminium  
*Bonding of Al-Li Base Alloys Using Roll Clad Zn Interlayers*
- Paper 24 WANG YANWEN, FENG ZEZHOUE and SUN SHANGCHEN, Beijing Research Institute of Mechanical and Electrical Technology of SCMI  
*Transformation Superplasticity Solid-state Bonding in Steels*
- Paper 25 P. G. PARTRIDGE and D. V. DUNFORD, Royal Aircraft Establishment  
*Effect of Superplastic Deformation on the Surface Roughness of Sheet*
- Paper 26 LI YOU-QIN and ZHANG SHI-LING, Beijing Aeronautical Manufacturing Technology Research Institute  
*Study on SPF and SPF/DB of the Bulkhead Structure with Nonsymmetric Shape*
- Paper 27 HAI JINTAO, LU XIN, YANG LUYI, ZHANG GUOPIN and BAI BINZHE, Beijing Research Institute of Mechanical and Electrical Technology of SCMI  
*Superplastic Forming of Ti-Alloy Turbine Blade*
- Paper 28 WANG CHENG and LUO YING-SHE, Xiangtan University  
*New Advance of Superplastic Forming Process for Commercial Structural Alloys*
- Paper 29 SONG YU-QUAN, Jilin University of Technology; ZHANG ZHEN-JUN, Chinese Academy of Agricultural Mechanization Sciences and LIAN SHU-JUN, Jilin University of Technology  
*Mechanical Analysis About Deformation Laws of Superplastic Extrusion Through Cone-shaped Dies*
- Paper 30 MURRAY W. MAHONEY and ROY CROOKS, Rockwell International Science Center  
*Mechanisms of Superplastic Flow in Inconel 718*
- Paper 31 HUANG LIPING, Shanghai Iron & Steel Research Institute  
*The Study of Reducing Superplastic Temperature in Ti Alloys*
- Paper 32 SU SHENGGUI, SHEN HUANXIANG and SONG SHENG-ZHE, Northeast Institute of Heavy Machinery  
*An Approach to the Superplasticity of Al Brass (HAL 66-6-3-2)*
- Paper 33 J. J. BLANDIN, Institut National Polytechnique de Grenoble; J. Y. LACROIX, Centre de Recherches et Développement Cégédur-Pechiney and M. SUÉRY, Institut National Polytechnique de Grenoble  
*Superplasticity and Cavitation of the 2091 Al-Cu-Li-Mg Alloy*

- Paper 34      WANG CHUNRONG, SONG HAILONG, QU LI and CHAO SHUZHI, Institute of<sup>4</sup>  
Metal Research, Academia Sinica  
*Superplastic Formability to Distinguish the Metallic Thin Wall Components by Criteria  
and Criterion-model*
- Paper 35      TONY BARNES, R. BUTLER, M. J. REYNOLDS, Superform Metals, R. GRIMES,  
and W. S. MILLER, Alcan International Ltd.  
*Forming Characteristics of Structural Al Alloys (Combined with "Forming  
Characteristics and Mechanical Properties of Superplastic Al-Li Based Alloys 8090 and  
8091")*
- Paper 36      ATUL H. CHOKSHI and AMIYA K. MUKHERJEE, University of California-  
Davis  
*The Influence of Hydrostatic Pressure on Cavitation and Failure in Superplastic Al-  
based Alloys*
- Paper 37      A. VARLOTEAUX, J. J. BLANDIN and M. SUÉRY, Institut National  
Polytechnique de Grenoble  
*Influence of Uni- and Bi-axial Straining on Cavitation in a Superplastic Al Alloy*
- Paper 38      K. HIGASHI, University of Osaka Prefecture and N. RIDLEY, University of  
Manchester/UMIST  
*Thermomechanical Processing and Superplasticity in a Commercial Cu-base Alloy*
- Paper 39      PARVIN SHARIAT, Northrup University and TERENCE G. LANGDON,  
University of Southern California  
*The Influence of Specimen Profile and Notch Geometry on Superplasticity in Zn-22%  
Al*
- Paper 40      CHEN HECHUN and YANG ZHENHENG, Northwestern Polytechnical University  
*The Relationship Between Strain-rate Sensitivity Index and Strain in Superplasticity*
- Paper 41      C. HAMMOND, A. NICHELLS, University of Leeds, and N. E. PATON, Rockwell  
International  
*Photoemission Electron Microscopy of Superplastic Deformation Mechanisms in Al  
Alloy 7475 and Ti Alloy Ti-6%Al-4%V*
- Paper 42      B. ASH and C. H. HAMILTON, Washington State University  
*Factors Affecting Superplastic Stability in an Al-Li-Cu-Zr Alloy*
- Paper 43      BINYAN REN and C. H. HAMILTON, Washington State University  
*The Microstructural Characteristics of an Al-Li-Cu-Mg-Zr Alloy During the Initial  
Stage of Superplastic Deformation*
- Paper 44      JIANZHONG CUI, QINLING WU and LONGXIANG MA, Northeast University of  
Technology  
*Effect of Grain Size on Region Transition Behavior in Superplastic Deformation*
- Paper 45      R. D. TUCKER and C. H. HAMILTON, Washington State University  
*The Effects of Superplastic Deformation on the Microstructure and Hardening  
Characteristics of High Strength 8091 Al-Li Alloy*
- Paper 46      L. R. ZHAO, S. Q. ZHANG and M. G. YAN, Institute of Aeronautical Materials  
*Details of the Alpha Grain Boundaries in Annealed and Superplastically Deformed Ti-  
6Al-4V Alloy*
- Paper 47      L. R. ZHAO, S. Q. ZHANG and M. G. YAN, Institute of Aeronautical Materials  
*Improvement in the Superplasticity of Ti-6Al-4V Alloy by Hydrogenation*

- Paper 48 Z. R. WANG, XU YANWU, GUO DIANJIANG, Harbin Institute of Technology, YIN CHANGKUI, Beijing Agricultural Engineering University  
*An Experimental Study of Yield Criteria Using Superplastic Thin-walled Tubes Subjected Tension-torsional Combined Loads*
- Paper 49 HAILING HUANG, Changchun Institute of Optics & Fine Mechanics Academia Sinica, QINGLING WU, Northeast University of Technology, and JIN HUA, Changchun Institute of Optics & Fine Mechanics Academia Sinica  
*A Study on Superplasticity of Commercial 2024Al Alloy*
- Paper 50 PAN YA QIN, LIU WEIMIN and SONG ZUOZHOU, Beijing Institute of Aeronautics and Astronautics  
*Superplasticity in Ti-10V-2Fe-3Al Alloy*
- Paper 51 XI JUKUI, XU CHUNHUA, and YANG YUNLIN, Luoyang Institute of Technology  
*Superplastic Boriding of Steel*
- Paper 52 J. WITTENAUER, P. SCHEPP and B. WALSER, Sulzer Brothers AG  
*Application of Superplastic UHC Steel for Isothermal Forging of Machine Component*
- Paper 53 ZHAO MIN and CHEN PUQUAN, Harbin Institute of Technology  
*A Complex Deformation Mechanism for Superplastic Deformation of Mg Alloys*
- Paper 54 JIN TAO, ZHAO MIN and CHEN PUQUAN, Harbin Institute of Technology  
*A Deformation Mechanism for Superplastic Deformation of Age Strengthening Cu Alloy*
- Paper 55 HAN SHUZHI, Northeast University of Technology  
*Study on Improving the Performance of Zn-22%Al Eutectoid Superplastic Alloys*
- Paper 56 J. F. YANG, PENG XU AND H. WANG, Harbin Institute of Technology  
*Effects of Second Phase Particles on the Cavity of Superplasticity*
- Paper 57 TAKAYUKI NAGANO, HIDEZUMI KATO, Suzuki Motor Co. Ltd. and FUMIHIRO WAKAI, Government Industrial Research Institute  
*Diffusion Bonding of  $ZrO_2/Al_2O_3$  Composite*

## TUESDAY, AUGUST 2

### SESSION IV: RHEOLOGY and CAVITATION Chair: Oleg Sherby, Stanford University, U.S.A.

#### Keynote Speaker

- 8:00 Paper 58 B. BAUDELET and M. SUÉRY, Institut National Polytechnique de Grenoble  
*Plastic Stability and Strain to Fracture During Superplastic Deformation*

#### Keynote Speaker

- 8:35 Paper 59 ATUL H. CHOKSHI and AMIYA MUKHERJEE, University of California-Davis  
*The Role of Cavitation in the Failure of Superplastic Alloys*

- 9:10 Paper 60 T. R. BIELER, University of California-Davis, T. G. NIEH, J. WADSWORTH, Lockheed Missiles and Space Co., Inc. and A. K. MUKHERJEE, University of California-Davis  
*High Rate Superplastic Behavior of Mechanically Alloyed Al IN90211*

- 9:30 Paper 61 H. OHSAWA, Hosei University  
*Effect of Accelerated/Decelerated Strain Rate on Sheet Formability of  $\sigma = K\dot{\epsilon}^m \epsilon^n$  Materials*
- 9:50 Break
- 10:10 Paper 62 YAN MA and TERENCE G. LANGDON, University of Southern California  
*An Investigation of the Characteristics of Cavitation in Superplastic Materials*
- 10:30 Paper 63 O. M. SMIRNOV, Moscow Steel and Alloys Institute  
*Rheological Criteria for Rational Use of Superplasticity in Metal Working by Pressure*
- 10:50 Paper 64 TAKUJI OKABE, Kure National College of Technology, TOMEI  
HATAYAMA, Hiroshima University and HIDEO TAKEI, Hiroshima  
Institute of Technology  
*Effect of Strain Rate Dependence of  $m$  on Ductility in Superplastic Materials*
- 11:10 Paper 65 J. J. BLANDIN and M. SUÉRY, Institut National Polytechnique de Grenoble  
*Evolution of Cavitation During Superplastic Deformation*
- 11:30 Paper 66 NORIO FURUSHIRO, Osaka University and TERENCE G. LANGDON,  
University of Southern California  
*An Experimental Investigation of Hole Growth and Interlinkage in the  
Superplastic Zn-22% Al Eutectoid Alloy*
- 11:50 Paper 67 ZHAO YOU-CHANG and LI XIU-QING, Jilin University  
*Cavitation Behavior and Dislocation Structure of Commercial Mn-Brass During  
Superplastic Deformation*
- 12:15 Lunch in Blakely Room

## TUESDAY, AUGUST 2

### SESSION V: FUNDAMENTALS OF FORMING

Chair: Peter Winkler, MBB, West Germany

#### Keynote Speaker

- 13:00 Paper 68 A. K. GHOSH, Rockwell International Science Center  
*Role of Microstructure and Mechanics on Superplastic Forming*

#### Keynote Speaker

- 13:35 Paper 69 MASARU KOBAYASHI, Technological University of Nagaoka  
*Novel Processing Methods for Superplastic Alloys*
- 13:55 Paper 70 N. CHANDRA and B. ROY, Florida State University  
*Membrane Element Analysis of Axisymmetric and Non-axisymmetric  
Superplastic Metal Forming Processes*
- 14:15 Paper 71 J. BONET, R. D. WOOD and O. C. ZIENKIEWICZ, University College of  
Swansea  
*Finite Element Modelling of the Superplastic Forming of Thin Sheet*
- 14:35 Break

- 14:50 Paper 72 J. M. STORY, Aluminum Company of America  
*Incorporation of Sliding Friction into a Closed-form Model of Plane Strain Superplastic Forming*
- 15:10 Paper 73 Z. X. GUO, University of Manchester/UMIST, J. PILLING, Michigan Technological University and N. RIDLEY, University of Manchester/UMIST  
*Bulge-forming of Domes: A Comparison of Theoretical Prediction and Experiment*
- 15:30 Paper 74 TAO SHUXUE and MA LONGXIANG, Northeast University of Technology  
*A Study on Superplastic Alloy Sheet Bulging Under the Microcomputer Control*
- 15:50 Paper 75 J.-L. LEBRUN, M. RESZKA and M. FOULON  
*Development of a Characterization Test of Materials and of the Parameters for Superplastic Forming of Al Alloys*
- 16:10 Paper 76 CHEN BINGKUN and HAI JINTAO, Beijing Research Institute of Mechanical and Electrical Technology of SCMI  
*Superplastic Forming of Ti-Alloy Vessel*
- 16:30 Paper 77 S. D. VISWANATHAN, S. VENKATASAMY and K. A. PADMANABHAN  
*Theoretical and Experimental Studies on the Pressure Thermo-forming of Hemispheres of Alloy Ti-6Al-4V*
- 16:50 Paper 78 B. PLEGE  
*On the Importance of Microstructure and Forming Parameters in the Manufacture of Ti-6Al-4V SPF/DB Parts*

Dinner on your own.

---

**WEDNESDAY, AUGUST 3**

**SESSION VI: ALLOY DESIGN**

Chair: Norman Ridley, University of Manchester/UMIST

**Keynote Speaker**

- 8:00 Paper 79 M. YAMAZAKI, National Research Institute for Metals, Japan  
*Alloy Design of Superplastic Ni-base and Ti-base Alloys*

**Keynote Speaker**

- 8:35 Paper 80 N. RIDLEY, University of Manchester/UMIST and C. HAMMOND, University of Leeds  
*Development of Superplastic Behaviour in Various Commercial Materials*

- 9:10 Paper 81 R. A. RICKS, Alcan International Limited and P.-J. WINKLER, MBB Central Laboratories  
*Superplastic Optimisation for Diffusion Bonding Applications in Al-Li Alloys*

- 9:30 Paper 82 ZHOU TIECHENG, ZHANG ZHIMIN, ZHANG YANHUI, Taiyuan Institute of Machinery and TANG DEFEN, Beijing Nonferrous Metals and Rare Earth Research Institute  
*The Development of LFC-X1 Alloy*

- 9:50 Break

- 10:10 Paper 83 R. CROOKS, Rockwell International Science Center, S. J. HALES and T. R. McNELLEY, Naval Postgraduate School  
*Microstructural Refinement via Continuous Recrystallization in a Superplastic Al Alloy*
- 10:30 Paper 84 K. MATSUKI, M. TOKIZAWA, Toyama University and G. STANIEK, Institut für Werkstoff-Forschung  
*Superplasticity of Rapidly Solidified 7475-0.7 Wt% Zr Alloys*
- 10:50 Paper 85 I. I. NOVIKOV and V. K. PORTNOY, Moscow Steel and Alloys Institute  
*Optimization of Heterogeneity as General Principle of Controlling Alloys Structure for Superplastic Forming*
- 11:10 Paper 86 S. YAMAZAKI, T. OKA, Y. MAE, Mitsubishi Metal Corp., and M. KOBAYASHI, Technological University of Nagaoka  
*Superplastic Properties of the Cold Formable Ti Alloy SP35*
- 11:30 Paper 87 I. KUBOKI, Y. MOTOHASHI and M. IMABAYASHI, Ibaraki University  
*Grain Refinement and Superplasticity in a Hard Ni-base Alloy*
- 12:15 Lunch in Blakely Room

### WEDNESDAY, AUGUST 3

#### SESSION VII: SPF METHODS and DIFFUSION BONDING Chair: Amit Ghosh, Rockwell International Science Center, U.S.A.

##### Keynote Speaker

- 13:50 Paper 88 J. PILLING, Michigan Technological University  
*Diffusion Bonding in Superplastic Materials*

##### Keynote Speaker

- 14:25 Paper 89 P.-J. WINKLER, MBB GmbH  
*Diffusion Bonding and Combined SPF*

- 15:00 Paper 90 HUANG YAN and MA LONGXIANG, Northeast University of Technology  
*A Dynamic Model for Diffusion Bonding of Metals*
- 15:20 Paper 91 YASUNORI SAOTOME, Gunma University and NOBUHIRO IGUCHI, Waseda University  
*Effects of Transformation Superplasticity on the Early Deformation Process of the Solid State Bonding in Pure Iron*
- 15:40 Break
- 15:55 Paper 92 J. KENNEDY, Grumman Corporation  
*Diffusion Bonding and Superplastic Forming of 7475 Al Alloy*
- 16:15 Paper 93 D. S. McDARMAID and P. G. PARTRIDGE, Royal Aircraft Establishment  
*Mechanical Properties of Ti and Al Alloys after Superplastic Deformation*
- 16:45 Paper 94 ZHANG DIXIANG, Radio Manufacture Factory  
*The Application of Superplastic Forming for Making Plastic Injection Mould*
- 17:05 Paper 95 MITSUJI HIROHASHI and HIROSHI ASANUMA, Chiba University  
*Combined Extrusion of Superplastic Al-Zn System Alloys*

- 17:25 Paper 96 YANG YONGCHUN, Beijing Research Institute of Mechanical and Electrical Technology  
*Superplastic Behaviour of Die Steel 4Cr-3Mo-3W-2V and Application*
- 

### WEDNESDAY, AUGUST 3

- 19:00 No-Host Social on the Terrace (weather permitting)  
 19:30 - 21:00 Salmon Banquet on the Terrace (weather permitting)

Purchase tickets for spouse and guests by August 1.

---

### THURSDAY, AUGUST 4

#### SESSION VIII: DESIGN CONCEPTS and FUTURE DIRECTIONS

Chair: Neil E. Paton, Rockwell International, U.S.A.

#### Keynote Speaker

- 8:00 Paper 97 HAI JINTAO, DAI JILIN, CHEN SANSHAN, Beijing Research Institute of Mechanical and Electrical Technology; Z. R. WANG AND ZHANG KAIFENG, Harbin Institute of Technology  
*Development of Superplastic Technology in China*

#### Keynote Speaker

- 8:35 Paper 98 R. RAJ, Cornell University  
*Mechanisms of Superplastic Deformation in Ceramics*
- 9:10 Paper 99 D. M. WARD, Incoform Limited  
*Forming Non-superplastic Materials with Superplastic Membranes*
- 9:30 Paper 100 BRUNO ROLLAND, Avions Marcel Dassault - Breguet Aviation  
*SPF-DB Applications for Military Aircraft*
- 9:50 Break
- 10:10 Paper 101 H. NISHIMURA, S. WAKAYAMA, H. YAMAMOTO, S. YAMAGISHI, Toyko Metropolitan University  
*Fabrication of Fiber Reinforced Metal Using Superplastic Metal Powder as Matrix*
- 10:30 Paper 102 FUMIHIRO WAKAI, Government Industrial Research Institute  
*Superplasticity of ZrO<sub>2</sub> Toughened Ceramics*
- 10:50 Paper 103 B. KELLETT, P. CARRY and A. MOCELLIN, Ecole Polytechnique de Lausanne  
*Extrusion of Tet-ZrO<sub>2</sub> at Elevated Temperatures*
- 11:10 Paper 104 T. HERMANSSON, Chalmers University of Technology, P. LAGERLÖF, Case Western Reserve University and G. DUNLOP, Chalmers University of Technology  
*Superplastic Deformation OF Y-TZP ZrO<sub>2</sub>*
- 11:30 Paper 105 Y. MUTOH, M. KOBAYASHI, Technological University of Nagaoka, Y. MAE and K. TOYOFUKU, Mitsubishi Metal Corp.  
*Post-SPF Fatigue Properties in Ti-6Al-4V Alloy*

- 11:50 Paper 106 G. W. HUGHES, S. H. JOHNSTON, and B. GINTY, British Aerospace Public Limited Company  
*The Manufacture of SPF Military Aircraft Doors in Al Alloy*
- 12:10 Paper 107 H. E. FRIEDRICH, M. KULLICK and R. FURLAN, MBB GmbH  
*SPF/DB on the Way to the Production Stage for Ti and Al Applications Within Military and Civil Projects*
- 12:30 - 1:30 Lunch in San Juan Ballroom.
- 

**THURSDAY, AUGUST 4**

12:45 - 6:50 OPTIONAL TOUR TO BOEING AIRCRAFT ASSEMBLY PLANT in Everett

Bus departs promptly at 12:50.

**HAVE A NICE TRIP HOME -- THANK YOU FOR COMING!**



## **APPENDIX B**

### **LIST OF ATTENDEES**

**International Conference on Superplasticity  
and Superplastic Forming**

**International Conference on Superplasticity  
and Superplastic Forming  
Blaine, Washington, U. S. A.  
August 1-4, 1988**

Suphal Agrawal  
Northrop Aircraft Division  
Hawthorne CA

Rodney Bahr  
Boeing Military Airplanes  
Wichita KS

Eric Barta  
Boeing Commercial Airplanes  
Seattle WA

Thomas Bieler  
Univ of California at Davis  
Davis CA

Jeanine Brantingham  
RMI Company  
Niles OH

Claude Carry  
Polytech Federale de Lausanne  
Lausanne Switzerland

Naman Chandra  
Florida State University  
Tallahassee FL

Atul Chokski  
Univ of California at Davis  
Davis CA

Peter Comley  
Murdock Inc.  
Compton CA

Jianzhong Cui  
Northeast Univ of Technology  
Shenyang China

Richard Delagi  
Texas Instruments Incorporated  
Attleboro MA

Gordon Dunlop  
Chalmers Univ of Technology  
Goteborg Sweden

Beverly Ash  
Rockwell International  
Canoga Park CA

A.J. Barnes  
Superform USA  
Riverside CA

Bernard Baudalet  
Inst. Nat'l Polytech de Grenoble  
Saint Martin D'Heres France

Javier Bonet  
University College of Swansea  
Swansea West Glam, Wales

J. Pierre Brunet  
Superform USA  
Riverside CA

Logan Casteel  
Superform USA  
Riverside CA

Wonjib Choi  
RIST  
Pohang Korea

Ye Chou  
Lehigh University  
Bethlehem PA

Roy Crooks  
Rockwell Int'l Science Center  
Thousand Oaks CA

Sheldon Cytron  
U.S. Army ARDEC  
Dover NJ

Kishore Desai  
Chem-Tronics  
El Cajon CA

Barry Dunwoody  
Superform Metals Limited  
Worcester England

Nicolay Dyulgerov  
Bulgarian Academy of Sciences  
Sofia Bulgaria

David Edmonds  
University of Oxford  
Oxford England

Philippe Fernandez  
Alusuisse  
Neuhausen Am Rheinfall SWITZERLAND

John Fowler  
Rolls Royce  
Colne Lancashire, England

Norio Furushiro  
Osaka University  
Suita Osaka, Japan

Ramon Goforth  
Texas A & M University  
College Station TX

Alfred Goldberg  
Lawrence Livermore Nat'l Lab  
Livermore CA

Howard Hamilton  
Washington State University  
Pullman WA

Thomas Hermansson  
Chalmers Univ of Technology  
Goteborg Sweden

Mitsuji Hirohashi  
Chiba University  
Chiba Japan

Gareth Hughes  
British Aerospace  
Lancashire England

Heinz Jaeger  
Hoogovens Aluminium GMBH  
Koblenz West Germany

Oskar Kaibyshev  
USSR Academy of Sciences  
Khalturina Ufa, USSR

Horst deLorenzi  
General Electric Corporation  
Schenectady NY

Allison Evans  
General Electric Aircraft  
Cincinnati OH

Daniel Fertton  
Cegedur Pechiney  
Voreppe France

Roberto Furlan  
Messerschmitt-Boelkow-Blohm  
Munich West Germany

Amit Ghosh  
Rockwell Int'l Science Center  
Thousand Oaks CA

Philippe Goin  
Alsthom-ACB  
Nantes France

Roger Grimes  
British Alcan Aluminium  
Banbury Oxon, England

Charles Heikkenen  
General Dynamics  
Fort Worth TX

Kenji Higashi  
Osaka University  
Sakai Osaka, Japan

Friedrich Horst  
Messerschmitt-Bolkow-Blohm  
Augsburg West Germany

Susan Hurd  
Lawrence Livermore Nat'l Lab  
Livermore CA

Bernt Jaensson  
Saab-Scania AB  
Linkoping Sweden

Stan Kan  
L & F Industries  
Huntington Park CA

Bruce Kellett  
Polytech Federale de Lausanne  
Lausanne Switzerland

Erzsebet Kovacs-Csetenyi  
Aluterv-Fki, Hungalu Centre  
Budapest Hungary

Manfred Kullick  
Messerschmitt-Bolkow-Blohm  
Munchen West Germany

Stuart Lengel  
Parker Metal Bellows  
Moor Park CA

Michael Luton  
Exxon Research & Engineering  
Annandale NJ

Nancy Mack  
Washington State University  
Pullman WA

Murray Mahoney  
Rockwell Int'l Science Center  
Thousand Oaks CA

Kenji Matsuki  
Toyama University  
Toyama Japan

Merrilea Mayo  
Sandia National Laboratories  
Albuquerque NM

Yoshinobu Motohashi  
Ibaraki University  
Hitachi Ibaraki, Japan

Gollapudi Murty  
Indian Institute of Technology  
Kanpur India

Takayuki Nagano  
Suzuki Motor Co Ltd  
Takatsuka Hamamatsu Japan

Hisashi Nishimura  
Tokyo Metropolitan University  
Tokyo Japan

Masaru Kobayashi  
Technical University of Nagaoka  
Nagaoka Japan

Isao Kuboki  
Ibaraki University  
Hitachi-Shi Ibaraki, Japan

Jean-Louis Lebrun  
ENSAM  
Paris France

Huang Liping  
Shanghai Iron & Steel Res Inst  
Shanghai China

Yan Ma  
University of S. California  
Los Angeles CA

Yoshiharu Mae  
Mitsubishi Metal Corp  
Ohmiya Saitama, Japan

Raj Malik  
Parker Metal Bellows  
Moor Park CA

George Mayer  
Institute for Defense Analyses  
Alexandria VA

Terry McNelley  
Naval Postgraduate School  
Monterey CA

Amiya Mukherjee  
Univ of California at Davis  
Davis CA

Yoshiharu Mutoh  
Nagaoka University of Technology  
Nagaoka Japan

Herman Nied  
General Electric  
Schenectady NY

William Nix  
Stanford University  
Stanford CA

Hiroaki Ohsawa  
Hosei University  
Kaganei Tokyo, Japan

Kuniaki Osada  
Nippon Yakin Kogyo Co  
Kawasaki Japan

Peter Partridge  
Royal Aircraft Estab  
Farnborough Hants England

Lynn Phillips  
LTV, Aircraft Products Group  
Dallas TX

Ron Rae  
Mtl Tool & Engineering  
Manchester CT

Ricky Ricks  
Alcan International Ltd  
Banbury England

Robert Ringrose  
Titanium International Ltd  
West Midlands England

Alan Rosenstein  
AFOSR/NE, Bolling A.F.B.  
Washington D.C.

Yasunori Saotome  
Gunma University  
Kiryu Gunma, Japan

Peter Schepp  
Sulzer Brothers Ltd  
Winterthur Switzerland

Frank Scrima  
L & F Industries  
Huntington Park CA

Oleg Sherby  
Stanford University/LLNL  
Livermore CA

Takuji Okabe  
Kure Nat'l College of Technology  
Kure Japan

Chris Owen  
Alcoa  
Bettendorf IA

Neil Paton  
Rockwell International  
Canoga Park CA

John Pilling  
Michigan Tech University  
Houghton MI

Rishi Raj  
Cornell University  
Ithaca NY

Norman Ridley  
University of Manchester  
Manchester England

Bruno Rolland  
Avions Marcel Dassault  
Saint Cloud France

Daniel Sanders  
The Boeing Company  
Seattle WA

Eiichi Sato  
Institute of Space & Astro Sci  
Kanagawa Japan

Dick Schwalie  
General Dynamics  
Fort Worth TX

Parvin Shariat  
Northrop University  
Los Angeles CA

Steven Speaker  
General Dynamics  
Fort Worth TX

Ivan Spirov  
Bulgarian Academy of Sciences  
Sofia Bulgaria

Michael Stowell  
TI Research  
Saffron Walden Essex, England

Richard Todd  
Oxford University  
Oxford England

Tibor Turmezey  
Aluterv-Fki, Hungalu Centre  
Budapest Hungary

Fumihiro Wakai  
Nagoya Industrial Research Inst.  
Nagoya Japan

Bennie Ward  
Reynolds Metals  
Richmond VA

Don Weisert  
Ontario Technologies Corp  
Vista CA

David Wilkinson  
McMaster University  
Hamilton Ontario Canada

Peter-Jurgen Winkler  
Messerschmitt-Boelkow-Blohm  
Munchen West Germany

Richard Wood  
University College of Swansea  
Swansea West Glam, Wales

Wang Yanwen  
Beijing Research Institute  
Beijing China

James Story  
Alcoa Laboratories  
Alcoa Center PA

Edmund Ting  
Grumman  
Bethpage NY

Gabriel Torres Villasenor  
Inst de Investigaciones en Mat.  
Mexico D.F. Mexico

Jeffrey Wadsworth  
Lockheed Missiles & Space Co  
Palo Alto CA

Shuichi Wakayama  
Tokyo Metropolitan University  
Setagayaku Tokyo, Japan

David Ward  
Incoform Bramah Ltd  
Sheffield England

Adrian Wilkinson  
The Boeing Company  
Seattle WA

Dave Willis  
Esco Corporation  
Portland OR

Jerry Wittenauer  
Sulzer Brothers Ltd  
Winterthur Switzerland

Michio Yamazaki  
Nat'l Research Inst for Metals  
Tokyo Japan

Min Zhao  
Harbin Institute of Technology  
Harbin China

INTERNATIONAL CONFERENCE ON  
SUPERPLASTICITY AND SUPERPLASTIC FORMING

Supplemental Roster

Werner Beck  
MBB  
Bremen, F.R.Germany

Gueozyui Botchvaz  
Institute of Light Alloys  
Moscow, U.S.S.R.

Alexandre Chadsky  
Institute of Light Alloys  
Moscow, U.S.S.R.

Atul Chokshi  
University of Calif.-Davis  
Davis, CA

Alberto M. Correa-Alvarez  
Zinalco Extrusions  
Mexico City, Mexico

Eugueni Griбанov  
USSR State Committee for Science  
Moscow, U.S.S.R.

Stephen J. Hales  
Naval Postgraduate School  
Monterey, CA

Syed M. Kadri  
McDonnell Douglas Aircraft Co.  
Long Beach, CA

James R. Kennedy  
Grumman Corporation  
Bethpage, NY

Matthew Kistner  
The Boeing Co. - Aerospace  
Seattle, WA

Chuck S. Lee  
McDonnell Douglas Astronautics Co.  
Huntington Beach, CA

T.G. Nieh  
Lockheed  
Palo Alto, CA

Ilia Novikov  
Moscow Steel and Alloys Institute  
Moscow, U.S.S.R.

Burkhard Plege  
Dornier GmbH  
Friedrickshafen, W. Germany

Nikolai Rakhmanov  
Metallurgical Plant  
Stupino, U.S.S.R.

Oleg Smirnov  
Moscow Steel and Alloy Institute  
Moscow, U.S.S.R.

Doraiswamy Viswanathan  
Anna University  
Madras, India

Zhongren L.R. Wang  
Harbin Institute of Technology  
Harbin, China

You chang Zhao  
Jiling University  
Changchun, China

Naohiro Ishioka  
University of Maine  
Orono, Maine

Jean Van Der Sanden  
Esco Europe S.A.  
Frameries, Belgium